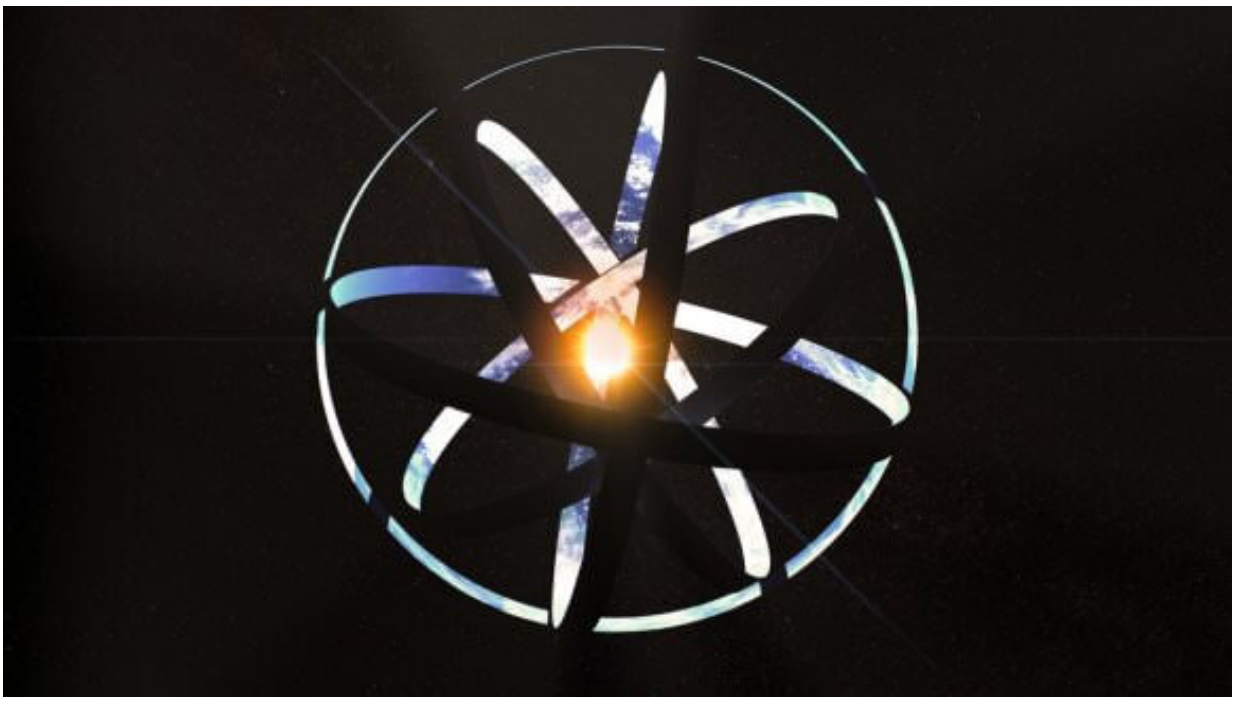
Calculate the number of alien civilizations in the Milky Way for yourself

June 25 2020, by Matt Williams



A new study has offered a new take on the Fermi Paradox – alien civilizations are not visible to us because they are sleeping. Credit: Kevin M. Gill

In recent years, the explosive nature of exoplanet discovery (over 4,164 confirmed so far) has led to renewed interest in the timeless question: "Are we alone in the universe?" Or, as famed Italian physicist Enrico Fermi put it, "Where is everybody?" With so many planets to choose from and the rate at which our instruments and methods are improving,

the search for life beyond Earth is really kicking into high gear.

At the same time, these discoveries have inspired many new studies regarding the ongoing search for extraterrestrial intelligence (SETI). This includes the Alien Civilization Calculator, which is the brainchild of physicists Steven Woodling and Dominick Czernia. Inspired by recent attempts to address the statistical likelihood of advanced life in our galaxy, they offer a mathematical tool that can crunch the numbers for you.

But first, a quick refresher seems in order. The first "calculator" for determining the number of extraterrestrial intelligences (ETIs) in our galaxy at any given time was created by American physicist and SETI researcher Dr. Frank Drake. During a meeting at the Green Bank Observatory in 1961, Drake prepared an equation which summed up the probabilities of finding ETIs in our galaxy.

Henceforth known as the Drake Equation, this probabilistic argument is expressed mathematically thus:

- N is the number of civilizations with which we could communicate
- R* is the average rate of star formation in our galaxy
- fp is the fraction of those stars which have planets
- ne is the number of planets that can support life
- fl is the number of planets that will develop life
- fi is the number of planets that will develop intelligent life
- fc is the number of civilizations that would develop transmission technologies
- L is the length of time that these civilizations would have to transmit their signals to space

While this equation was intended to stimulate debate about the

probability of ETIs, it was also significant because of its basic implications. Even if one treats all the variables conservatively, they still get an N result in the dozens or the hundreds. Basically, even if life is very rare in our galaxy, there ought to be at least a few civilizations out there that we could make contact with.

Over the years, the Drake Equation has received its fair share of criticism and many attempts have been made to refine it. For instance, in a recent paper that appeared in the *Astrophysical Journal*, astrophysics Tom Westby and Christopher J. Conselice from the University of Nottingham created a probabilistic argument of their own based on the Astrobiological Copernican Principle.

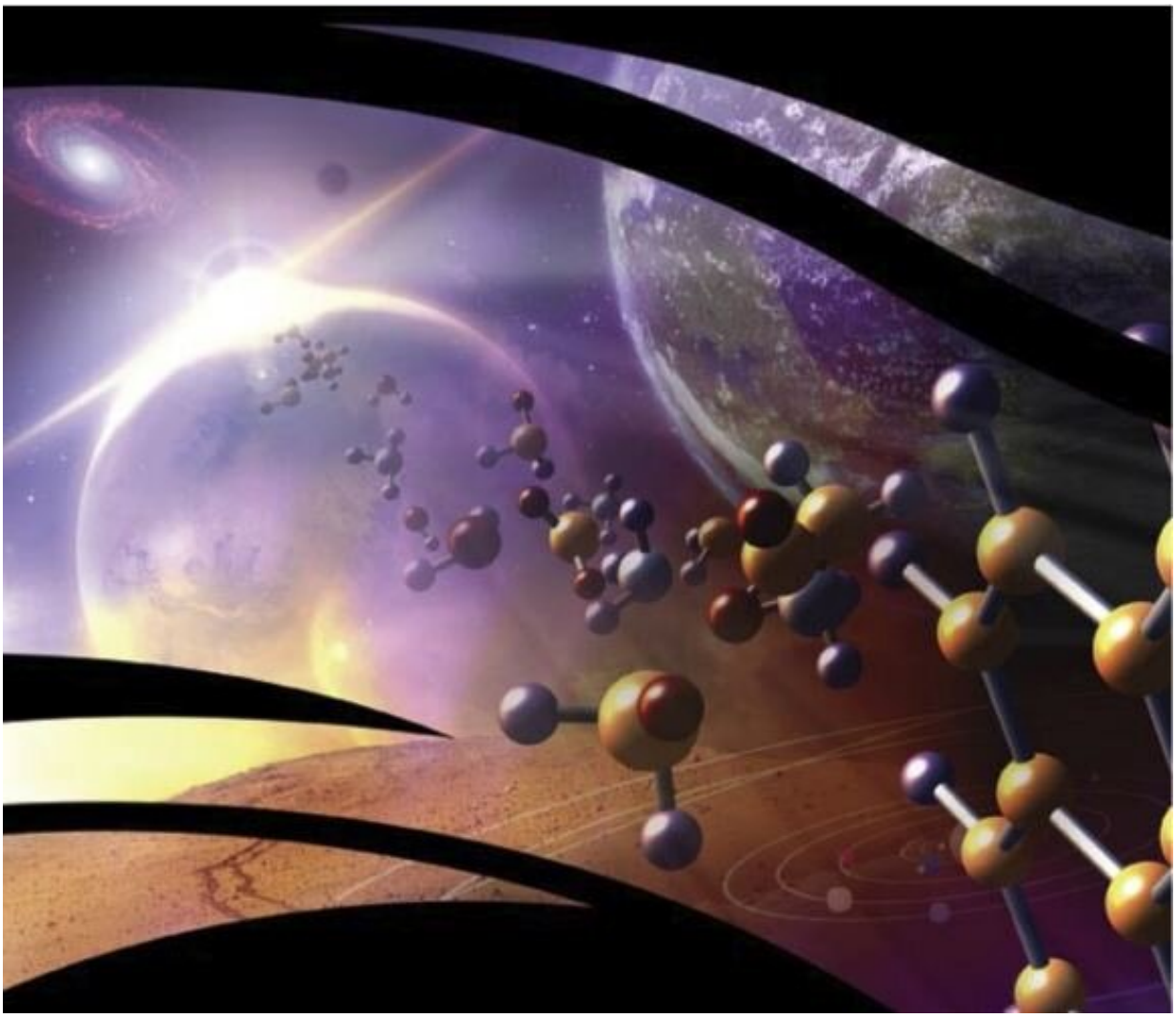
Put simply, this principle (when applied to the existence of life in our universe) states that in lieu of other evidence, one should never assume that humanity is special or unique. When applied to the question of whether or not humanity is alone in the universe, Wetsby and Conselice were able to produce a modern version of the Drake Equation. Mathematically, it can be expressed as:

$$N = N_* * F_L * F_{HZ} * F_M * (L/T')$$

- N is the number of civilizations we can communicate with
- N* is the total number of stars within the galaxy
- fL is the percentage of those stars that are at least 5 billion years old
- fHZ is the percentage of those stars which host a suitable planet for supporting life
- fM is the percentage of those stars with sufficient metallicity, allowing for advanced biology and an advanced civilization
- L is the average lifetime of an advanced civilization
- t' is the average amount of time available for life to develop

Combined with the latest astrophysical data on these values, they came up with an average estimate of 36 civilizations. This research paper inspired Wooding and Czernia to create their Alien Civilizations Calculator (ACC), a tool that would allow people to make their calculations using either the Drake Equation or the Astrobiological Copernican Principle, but in an interactive way.

In addition to being a member of the Institute of Physics (IOP) in the UK, Wooding is a regular contributor to The Omni Calculator Project—a small community made up of professionals who want to make science accessible.



The Drake Equation and the Astrobiological Copernican Principle both seek to address the burning question: "Are We Alone?" Credit: NASA

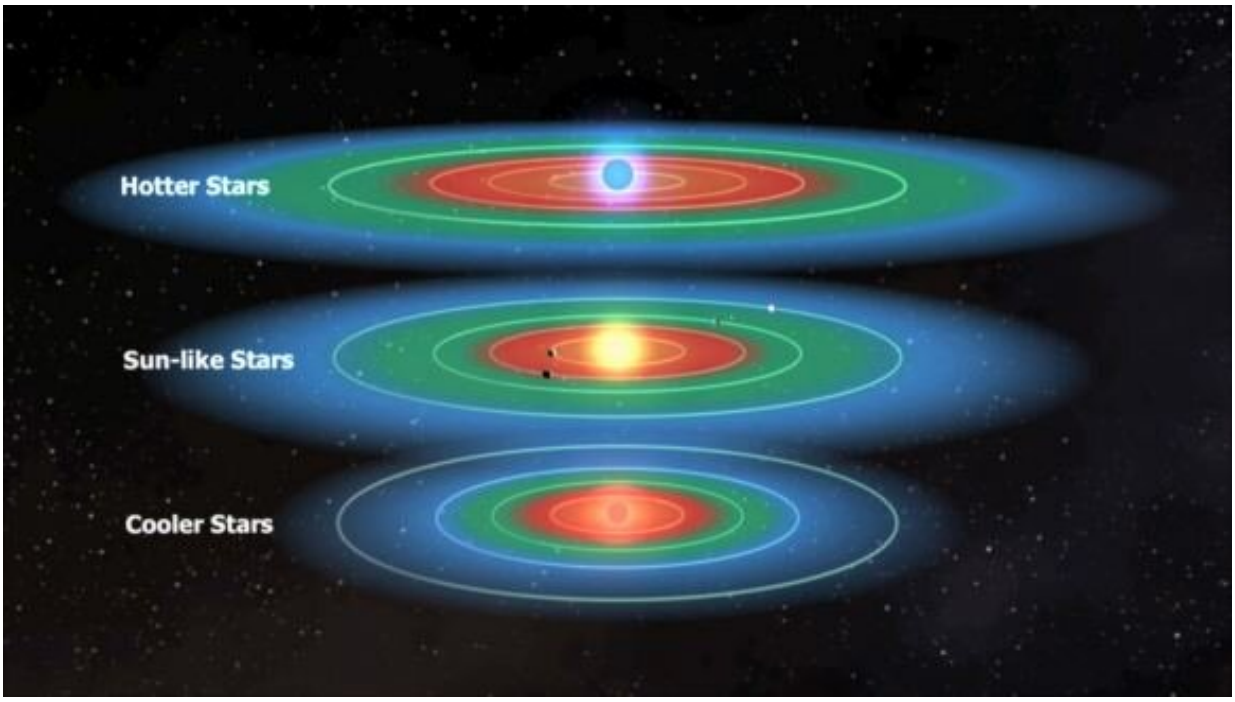
It was here that he met Czernia, a young molecular physicist currently completing his Ph.D. with the Institute of Nuclear Physics in Poland. Wooding explained to Universe Today via email: "As an interactive and fun way to engage the public in the science of this fundamental question 'Are we alone in the universe?,' The calculator allows people to easily see what inputs go into such a model and see how changing the values affect the result—more interactive than reading a scientific paper, which the vast majority won't do."

Those who want to use the ACC must first select the model they want to use, then fill in all the fields in the model assumptions section. Some default values are provided based on what scientists believe is statistically most likely, but users are free to enter whatever values they desire. From this, they will see how many intelligent civilizations their model and values predict.

The Astrobiological Copernican Principle is recommended since it is the more current model, and can be adjusted to allow for a weak, moderate or strong scenario. In other words, users can adjust how strict the conditions are for the formation of extraterrestrial life. However, users are encouraged to use both this and the Drake Equation to see how it affects their results.

Another benefit of the Copernican Principle model is that it allows users to see how long it would take to reach the nearest extraterrestrial neighbor. Wooding says, "[Users] should start by exploring the three

modeling scenarios and see how the inputs and results change. The strong scenario is very restrictive and closely follows how life has developed on Earth. The weak scenario has more relaxed assumptions and leads to a greater number of alien civilizations. Then you can put your own values in the calculator to see how the results change—great for armchair astrobiologists."



Artist's impression of the range of habitable zones for different types of stars. Credit: NASA/Kepler Mission/Dana Berry

Once users have done that, they can use the space travel calculator to see how long it would take to meet the nearest extraterrestrial civilizations in our galaxy. This calculator was also created by Czernia and similarly relies on user variables such as spacecraft mass, acceleration and physics models of the universe (Einsteinian or Newtonian).

For fun, let's assume that the ACC told us that there were potentially hundreds of civilizations in our galaxy and that the nearest one is located about 159 light-years away (using exoplanet HD 42936 Ab as a reference). Let us also assume we had a ship that is similar in mass to the ISS (420 metric tons, 463 U.S. tons) and that it could accelerate 1 g (9.8 m/s) until we reached 99% the speed of light.

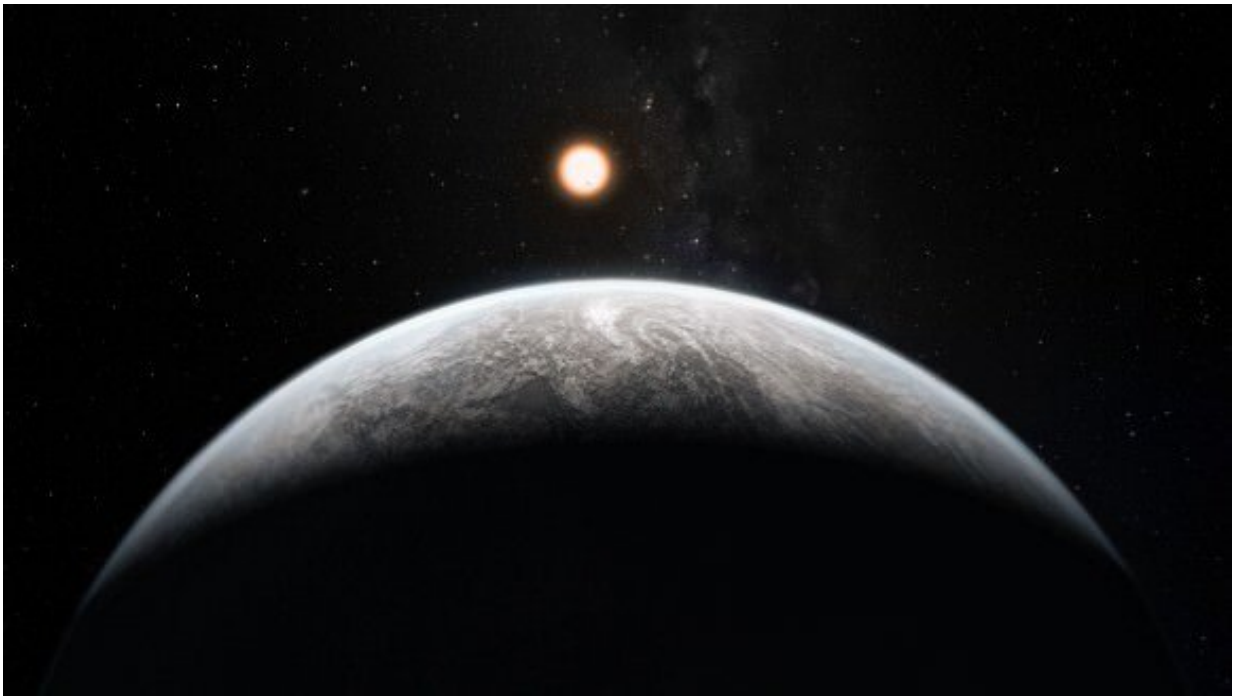
Based on these variables, the Space Travel Calculator tells us that it would take 161.4 years to reach the nearest ETI, though only 10 years would pass for the crew (since we're using Einsteinian physics). Apparently, the ship would also need about 11.66 million metric tons (12.85 million U.S. tons) of fuel mass to make the journey. So yeah, that mission won't be happening anytime soon. But it was a fun exercise that I highly recommend.

To be fair, both the Drake Equation and the Astrobiological Copernican Principle have their limitations. For example, we have learned a great deal since Drake first proposed his famous equation about the first four variables. Much of this is due to the recent spate of exoplanet discoveries, which have given astronomers a good idea of how many stars have planets, and how often they orbit within a star's habitable zone.

Similarly, the Astriobiological Copernican Principle is subject to a lot of uncertainty. In Westby and Conselice's study, they assumed that an Earth-like planet would eventually form life. In addition, it is widely assumed that since modern humans only emerged about 200,000 years ago (whereas planet Earth is over 4.5 billion years old), that SETI should only be looking at stars that are 4.5 billion years or older.

In the end, predicting how many extraterrestrial civilizations are out there will continue to involve a lot of uncertainty. As time goes on, and the instruments we use to conduct SETI research improve, astronomers

will learn more about these variables. From this, we can expect that estimates on the likely number of ETIs in our galaxy to become more tightly constrained.



Artist's impression of a Super-Earth planet orbiting a Sun-like star. Credit: ESO/M. Kornmesser

As Wooding indicated, some significant developments need to happen before we can answer the question "Are we alone?" with any confidence:

"Maybe in the future, as more discoveries are made about the stars and planets in the Milky Way, you could come back to the calculator and see how they affect the number of possible alien civilizations.

"We will get better at detecting Earth-like planets in the habitable zone

and even be able to detect what's in their atmospheres (if they have one). This might lead to a more targeted SETI search, which should increase our chances. I always thought of building a radio telescope on the dark side of the moon as a great idea to get away from the radio noise of the Earth, enabling us to increase our sensitivity to any alien transmissions."

In the end, we will not know for sure how likely extraterrestrial life and civilizations are until we find evidence. But the beauty part is that the Fermi Paradox ("Where is everybody?") only needs to be resolved once. In the meantime, the search for ETIs will continue, and will benefit immensely from next-generation instruments, like the James Webb and Nancy Grace Roman space telescopes, and methods that are becoming available.

At the same time, probability studies and probabilistic arguments will help us narrow the search parameters. If they are out there, we are sure to find them eventually (fingers crossed). Also, be sure to check out the other interesting tools that Omni Calculator has to offer, which include astrophysics, quantum physics, and other scientific calculators.

More information: Tom Westby et al. The Astrobiological Copernican Weak and Strong Limits for Intelligent Life, *The Astrophysical Journal* (2020). DOI: 10.3847/1538-4357/ab8225

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